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I, JONNE YABSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2002953111 for a patent by U.S. FILTER WATER & WASTEWATER GROUP, INC. as filed on 05 December 2002.

I further certify that the name of the applicant has been amended to U.S. FILTER WASTEWATER GROUP, INC. pursuant to the provisions of Section 104 of the Patents Act 1990.

WITNESS my hand this
Twenty-third day of December 2003

JONNE YABSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES



AUSTRALIA

PATENTS ACT 1990

PROVISIONAL SPECIFICATION

FOR THE INVENTION ENTITLED:-

"MIXING CHAMBER"

The invention is described in the following statement:-

TITLE: MIXING CHAMBER

TECHNICAL FIELD

The present invention relates to apparatus and related methods for use of a chamber
5 in association with membrane filtration modules to provide improved fluid distribution and
flow into the associated modules.

BACKGROUND OF THE INVENTION

The importance of membrane for treatment of waste water is growing rapidly. It is
now well known that membrane processes can be used as an effective tertiary treatment of
10 sewage and provide quality effluent. However, the capital and operating cost can be
prohibitive. With the arrival of submerged membrane processes where the membrane
modules are immersed in a large feed tank and filtrate is collected through suction applied
to the filtrate side of the membrane, membrane bioreactors combining biological and
physical processes in one stage promise to be more compact, efficient and economic. Due
15 to their versatility, the size of membrane bioreactors can range from household (such as
septic tank systems) to the community and large-scale sewage treatment.

The success of a membrane filtration process largely depends on employing an
effective and efficient membrane cleaning method. Commonly used physical cleaning
methods include backwash (backpulse, backflush) using a liquid permeate or a gas,
20 membrane surface scrubbing or scouring using a gas in the form of bubbles in a liquid.
Examples of the second type of method is illustrated in United States Patent no 5,192,456
to Ishida et al, United States Patent No. 5,248,424 to Cote et al, United States Patent No.
5,639,373 to Henshaw et al, United States Patent No. 5,783,083 to Henshaw et al and our

PCT Application No. WO98/28066.

In the examples referred to above, a gas is injected, usually by means of a pressurised blower, into a liquid system where a membrane module is submerged to form gas bubbles. The bubbles so formed then travel upwards to scrub the membrane surface to remove the fouling substances formed on the membrane surface. The shear force produced largely
5 relies on the initial gas bubble velocity, bubble size and the resultant of forces applied to the bubbles. The fluid transfer in this approach is limited to the effectiveness of the gas lifting mechanism. To enhance the scrubbing effect, more gas has to be supplied. However, this method has several disadvantages: it consumes large amounts of energy,
10 possibly forms mist or froth flow reducing effective membrane filtration area, and may be destructive to membranes. Moreover, in an environment of high concentration of solids, the gas distribution system may gradually become blocked by dehydrated solids or simply be blocked when the gas flow accidentally ceases.

For most capillary membrane modules, the membranes are flexible in the middle
15 (longitudinal direction) of the modules but tend to be tighter and less flexible towards to both potted heads. When such modules are used in an environment containing high concentrations of suspended solids, solids are easily trapped within the membrane bundle, especially in the proximity of two potted heads. The methods to reduce the accumulation of solids include the improvement of module configurations and flow distribution when gas
20 scrubbing is used to clean the membranes.

Our earlier International Application No. WO 00/18498 describes the use of a mixture of gas and liquid to effectively clean the surface of membranes. The arrangements and methods described herein provided another simple way of achieving effective scouring of membrane surfaces.

The present invention, at least in its embodiments, seeks to overcome or least ameliorate some of the disadvantages of the prior art or at least provide the public with a useful alternative.

According to one aspect the present invention provides a membrane module including a plurality of porous membranes extending in an array and mounted, at least at one end, in a header, said header having a number of distribution apertures for distributing a fluid into said module and along a surface or surfaces of said membranes, an elongate chamber having one open end and another end in fluid communication with said distribution apertures for distributing said fluid to said distribution apertures.

In one form of the invention, the fluid may be gas, usually air and in another form the invention the fluid may be a mixture of gas and liquid, usually air and feed liquid.

Preferably, the length of said chamber is greater than that required to provide a static head, when the membrane is immersed in a liquid and gas introduced into the chamber, equivalent to the head loss for the gas to flow to said distribution apertures. That is, the length of the chamber should be sufficient that all gas flows from the supply source or manifold through the distribution apertures rather than the open end of the chamber.

According to another aspect, the present invention provides a method of removing a fouling material from a plurality of porous hollow fiber membranes mounted and extending longitudinally in an array to form a membrane module, the method comprising the steps of:

providing a source of gas within a chamber in fluid communication with said membrane module;

flowing the gas from the chamber into a base of the membrane module to form gas bubbles therein when said module is immersed in a liquid, whereby an upward flow of the gas bubbles across surfaces of the hollow fiber membranes is obtained, and whereby fouling materials are dislodged from the surfaces of the porous hollow fiber membranes.

Preferably, said chamber is elongate with one end open and the other end in fluid communication with the membrane module. For preference, the gas is provided through the open end of the chamber.

According to another aspect, the present invention provides a method of removing a
5 fouling material from a plurality of porous hollow fiber membranes mounted and extending longitudinally in an array to form a membrane module, the method comprising the steps of:

forming a mixture of gas bubbles and liquid within a mixing chamber;

injecting the mixture into a base of the membrane module, whereby an upward flow of the mixture across surfaces of the hollow fiber membranes is obtained, and whereby
10 fouling materials are dislodged from the surfaces of the porous hollow fiber membranes.

For preference, the step of forming a mixture includes entraining the gas bubbles into a liquid stream. Preferably, the gas bubbles are entrained into said liquid stream by means of the chamber. For further preference, the gas bubbles are entrained or injected into said liquid stream by means of devices which forcibly mix gas into a liquid flow to produce a
15 mixture of liquid and bubbles, such devices including a jet, nozzle, ejector, eductor, injector or the like. The gas used may include air, oxygen, gaseous chlorine or ozone. Air is the most economical for the purposes of scrubbing and/or aeration. Gaseous chlorine may be used for scrubbing, disinfection and enhancing the cleaning efficiency by chemical reaction at the membrane surface. The use of ozone, besides the similar effects mentioned
20 for gaseous chlorine, has additional features, such as oxidising DBP precursors and converting non-biodegradable NOM's to biodegradable dissolved organic carbon.

According to a further aspect, the present invention provides a membrane module comprising a plurality of porous membranes, said membranes being arranged in close proximity to one another, a mixing chamber in fluid communication with said module for
25 mixing together liquid and gas bubbles to provide a cleaning mixture and means for

flowing said cleaning mixture along the surface of said membranes to dislodge fouling materials therefrom.

According to one preferred form, the present invention provides a method of removing fouling materials from the surface of a plurality of porous hollow fibre
5 membranes mounted and extending longitudinally in an array to form a membrane module, said membranes being arranged in close proximity to one another, the method comprising the steps of forming a mixture of gas bubbles and liquid within a mixing chamber, said mixture being formed by said gas bubbles being entrained in said liquid by flowing said liquid past a source of gas so as to cause said gas to be drawn and/or mixed into said
10 liquid, flowing said mixture into said membrane module such that said bubbles pass substantially uniformly between each membrane in said array to, in combination with said liquid flow, scour the surface of said membranes and remove accumulated solids from within the membrane module.

For preference, the membranes comprise porous hollow fibres, the fibres being fixed
15 at each end in a header, the lower header having one or more holes formed therein through which mixture of gas/liquid is introduced from the mixing chamber. The holes can be circular, elliptical or in the form of a slot. The fibres are normally sealed at the lower end and open at their upper end to allow removal of filtrate, however, in some arrangements, the fibres may be open at both ends to allow removal of filtrate from one or both ends. It
20 will be appreciated that the cleaning process described is equally applicable to other forms of membrane such flat or plate membranes.

According to yet a further aspect, the present invention provides a membrane module for use in a membrane bioreactor including a plurality of porous hollow membrane fibres extending longitudinally between and mounted at each end to a respective potting
25 head, said membrane fibres being arranged in close proximity to one another, said fibres

being partitioned into a number of bundles at least at or adjacent to their respective potting head so as to form a space therebetween, a mixing chamber connected or open to a source of gas and liquid, one of said potting heads having an array of openings formed therein in fluid communication with said chamber for providing gas bubbles within said module such
5 that, in use, said bubbles move past the surfaces of said membrane fibres to dislodge fouling materials therefrom.

The liquid used may be the feed to the membrane module. The fibres and/or fibre bundles may cross over one another between the potting heads though it is desirable that they do not.

10 Preferably, the fibres within the module have a packing density (as defined above) of between about 5 to about 70% and, more preferably, between about 8 to about 55%.

For preference, said holes have a diameter in the range of about 1 to 40 mm and more preferably in the range of about 1.5 to about 25 mm. In the case of a slot or row of holes, the open area is chosen to be equivalent to that of the above holes.

15 Typically, the fibre inner diameter ranges from about 0.1 mm to about 5 mm and is preferably in the range of about 0.25 mm to about 2 mm. The fibres wall thickness is dependent on materials used and strength required versus filtration efficiency. Typically wall thickness is between 0.05 to 2 mm and more often between 0.1 mm to 1 mm.

According to another aspect, the present invention provides a membrane bioreactor
20 including a tank having means for the introduction of feed thereto, means for forming activated sludge within said tank, a membrane module according to the first aspect positioned within said tank so as to be immersed in said sludge and said membrane module provided with means for withdrawing filtrate from at least one end of said fibre membranes.

25 According to yet another aspect, the present invention provides a method of operating

a membrane bioreactor of the type described in the above aspect comprising introducing feed to said tank, applying a vacuum to said fibres to withdraw filtrate therefrom while periodically or continuously supplying a cleaning mixture of gas bubbles and liquid formed in a mixing chamber through said openings to within said module such that, in use, said
5 cleaning mixtures flows along the surface of said membrane fibres to dislodge fouling materials therefrom.

If required, a further source of aeration may be provided within the tank to assist microorganism activity. For preference, the membrane module is suspended vertically within the tank and said further source of aeration may be provided beneath the suspended
10 module. Preferably, the further source of aeration comprises a group of air permeable tubes. The membrane module may be operated with or without backwash depending on the flux. A high mixed liquor of suspended solids (5,000 to 20,000 ppm) in the bioreactor has been shown to significantly reduce residence time and improve filtrate quality. The combined use of aeration for both degradation of organic substances and membrane
15 cleaning has been shown to enable constant filtrate flow without significant increases in transmembrane pressure while establishing high concentration of MLSS. The use of partitioned fibre bundles enables higher packing densities to be achieved without significantly compromising the gas scouring process. This provides for higher filtration efficiencies to be gained.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 shows a pictorial side elevation of a chamber and membrane modules

according an embodiment of the invention;

Figure 2 shows a pictorial side elevation of a chamber and membrane modules according a second embodiment of the invention;

Figure 3 shows a pictorial side elevation of a chamber and membrane modules
5 according a third embodiment of the invention;

Figure 4 shows a pictorial side elevation of a chamber and membrane modules according a fourth embodiment of the invention;

Figure 5 shows a pictorial side elevation of a chamber and membrane modules according a fifth embodiment of the invention; and

10 Figure 6 shows a schematic side elevation of a chamber and membrane module according a sixth embodiment of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to the drawings, the embodiments of the invention will be described in relation to a membrane module of the type disclosed in our earlier PCT application Nos.
15 WO98/28066 and WO00/18498 which are incorporated herein by cross-reference, however, it will be appreciated that the invention is equally applicable to other forms of membrane module.

As shown in Figure 1, the membrane module 5 typically comprises fibre, tubular or flat sheet form membranes 6 potted into a pot 7 which is supported by a header 8. The
20 membranes are typically encased in a support structure (not shown). In the embodiment shown, the headers 8 are coupled to a clover type manifold 9 which is turn is connected to an open ended elongate chamber 10 positioned below the manifold 9. The membrane module is typically immersed in a feed tank and either one or both ends of the membranes

may be used for the permeate collection. The bottom of each membrane module 5 has a number of through apertures 11 in the pot 7 to distribute gas or a mixture of gas and liquid feed past the membrane surfaces.

Figure 2 shows an embodiment where the chamber 10 is used to produce a liquid/gas bubble mixture by providing a source of gas 12 within the chamber 10 and flowing feed liquid through the chamber 10 to mix with gas bubbles produced from the gas source 12. In this embodiment the gas is fed from above through the clover manifold 9 as the membrane modules are typically suspended vertically in a feed tank, however, it will be appreciated that the gas may be provided to the chamber by any desired arrangement. The chamber 10 is open at its base 13 and liquid is flowed from a pipe 14 upwardly through the chamber 10 to mix with gas provided from a source 12 within the chamber 10. If necessary, a non-return valve (not shown) or the like may be attached to the gas source 12 to prevent the liquid phase entering the gas manifold 9.

The two fluids are mixed within the chamber 10 before being fed and uniformly distributed into the membrane modules 5 via the distribution apertures 11. The chamber 10 may be directly connected to a gas source 12 and/or liquid or as a capture and mixing device.

Referring to Figure 3, the chamber is shown in its application as a device to capture gas and/or liquid flow injected beneath it at its base 13. The fluid flow energy is therefore concentrated in the chamber 10 before distribution into the membrane modules 5. In this arrangement the chamber 10 is again open-ended at its base 13 but gas or liquid is provided from a source, in this case a pipe 14, below the open end and the chamber is used to capture the upward flow of these fluids for communication to the distribution apertures 11.

A similar embodiment is shown in Figure 4. In this embodiment, a venturi device 15 or the like is positioned at the base 13 of the chamber 10. The venturi device 15 intakes

gas through inlet 16, mixes or entrains the gas with liquid flowing through feed inlet 17, forms gas bubbles and diffuses the liquid/gas mix into the chamber 10. The liquid/gas mixture passes upwardly from the chamber 10 into the lower header 8 and through the distribution apertures 11. Liquid feed is also drawn through the open end of the chamber

5 10 by liquid/gas flow from the venturi device 15. The entrained gas bubbles scrub membrane surfaces while travelling upwards along with the liquid flow. Either the liquid feed or the gas can be a continuous or intermittent injection depending on the system requirements. With a venturi device it is possible to create gas bubbles and aerate the system without a blower. The venturi device 15 can be a venturi tube, jet, nozzle, ejector,

10 eductor, injector or the like.

Although the embodiments of Figures 3 and 4 are shown with an open-ended chamber 10, it will be appreciated that a closed chamber may be used with gas and liquid being directly injected into the chamber.

The liquid commonly used to entrain the gas is the feed water, wastewater or mixed

15 liquor to be filtered. Pumping such an operating liquid through a venturi or the like creates a vacuum to suck the gas into the liquid, or reduces the gas discharge pressure when a blower is used. By providing the gas in a flow of the liquid, the possibility of blockage of the distribution apertures 11 is substantially reduced.

The arrangement shown in the embodiment of Figure 5 also serves to reduce the

20 likelihood of blockage of the distribution apertures 11 by large particles. In this arrangement gas, typically air, is injected into the clover manifold 9 and the chamber 10 is lengthwise dimensioned to be greater than that required to provide a static head, when the membrane is immersed in a liquid and gas introduced into the chamber 10, equivalent to the head loss for the gas to flow to said distribution apertures 11. As can be seen from the

25 figure, as gas enters from above it forces the liquid within the chamber 10 downwards until

the gas flowing through the distribution apertures 11 equalizes the pressure within the chamber 10 and forms a liquid seal 18 to prevent gas passing outward through the lower open end 13 of the chamber 10. Such an arrangement has been found to prevent large particles within the feed liquid flowing into and blocking the distribution apertures 11.

5 These large particles usually remain within the chamber 10 and settle under gravity following which they can be removed during the usual drain down of the feed tank.

Figure 6 shows a similar arrangement to Figure 3 but with a single membrane module 5. Chamber 10 again captures gas or liquid/gas flow from source 12 and distributes the flow to apertures 11 in pot 7. The flow then passes upwardly between the membranes 6. 10 In the embodiment shown filtrate is withdrawn from the upper header 19 and a screen 20 is provided between the headers to support the membranes 6.

It will be appreciated that further embodiments and exemplifications of the invention are possible without departing from the spirit or scope of the invention described.

Dated this 5th day of December, 2002

15 USFilter Water & Wastewater Group, Inc.

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Fellow Institute of Patent and Trade Mark Attorneys of Australia
of BALDWIN SHELSTON WATERS

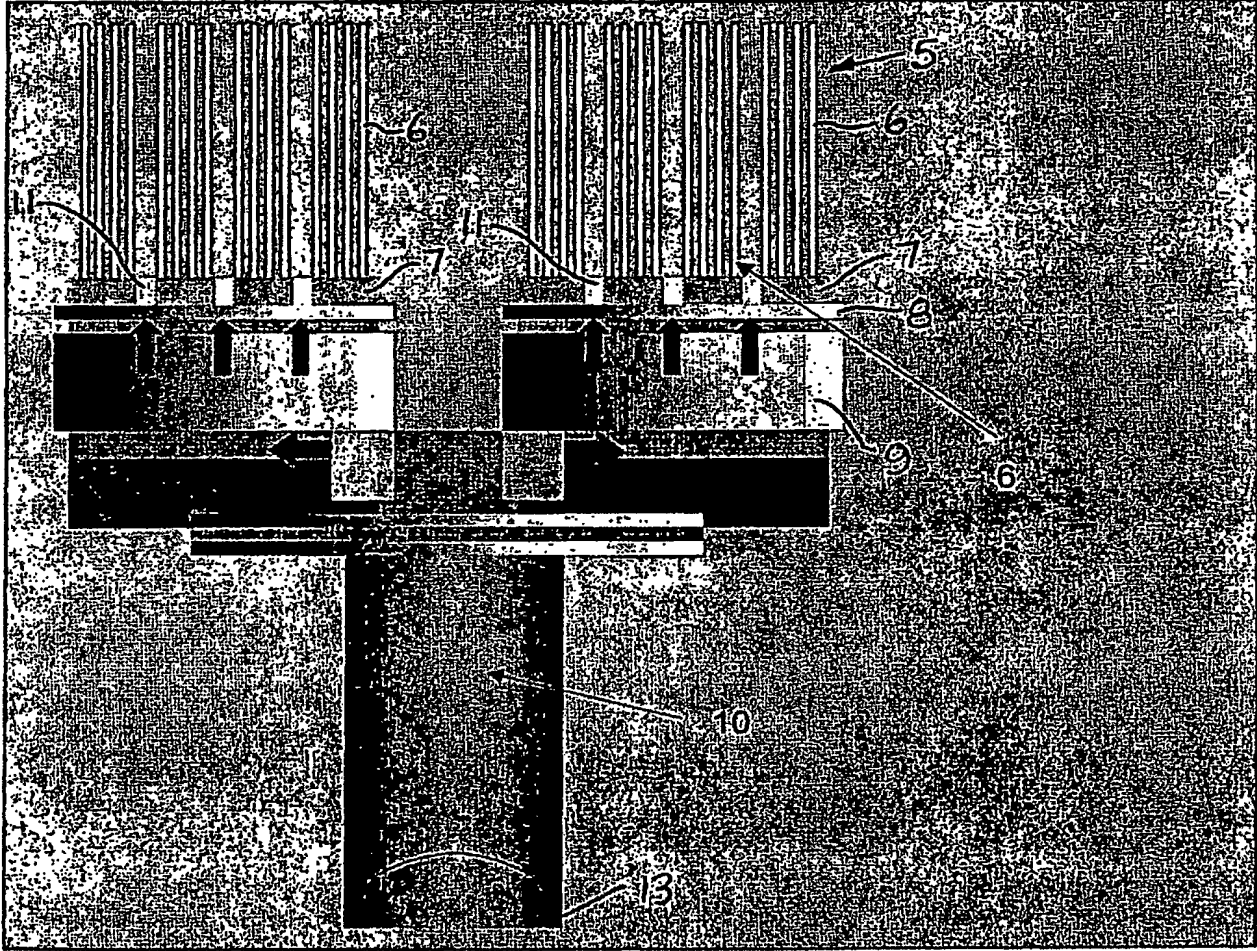


Fig 1

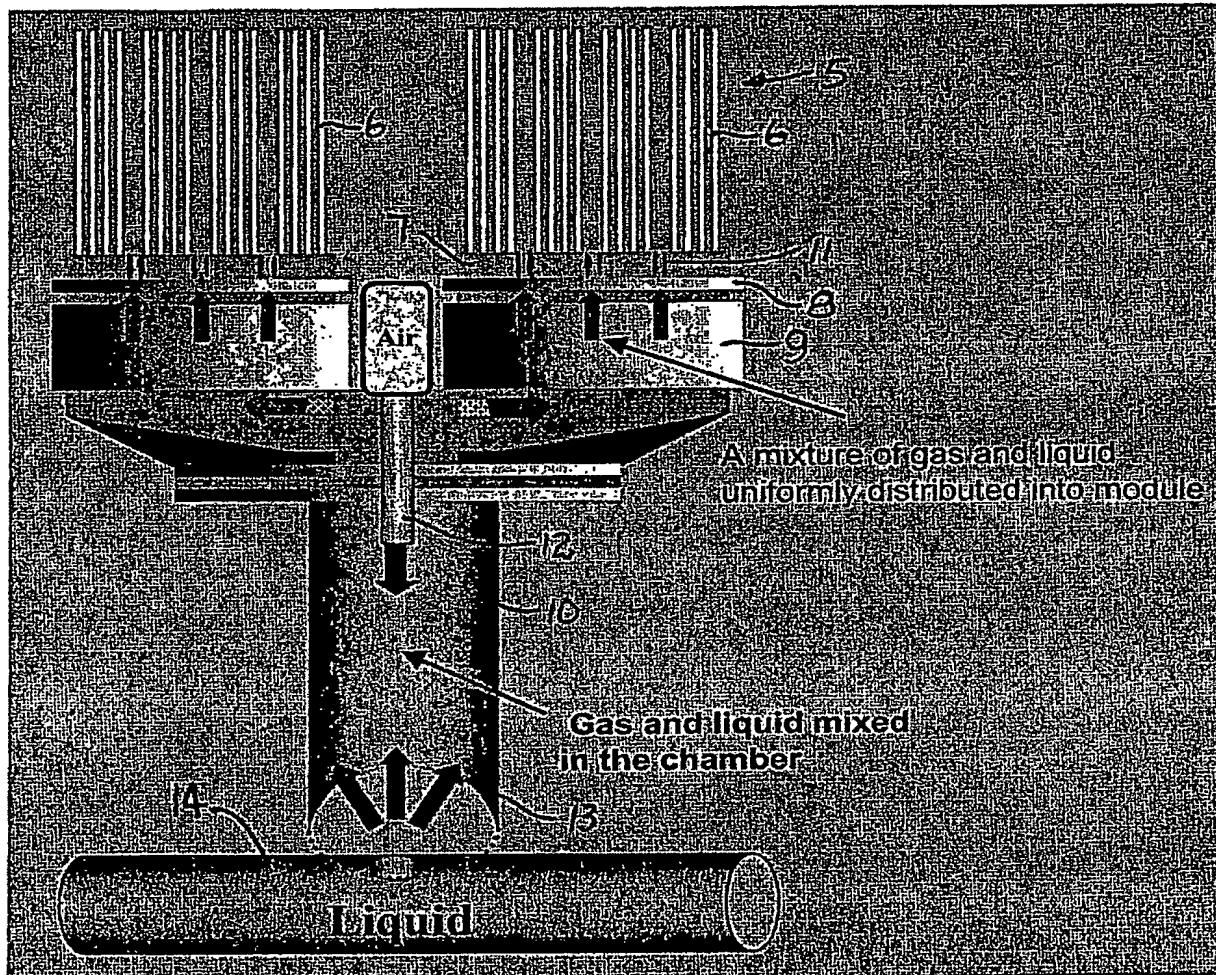


FIG. 2

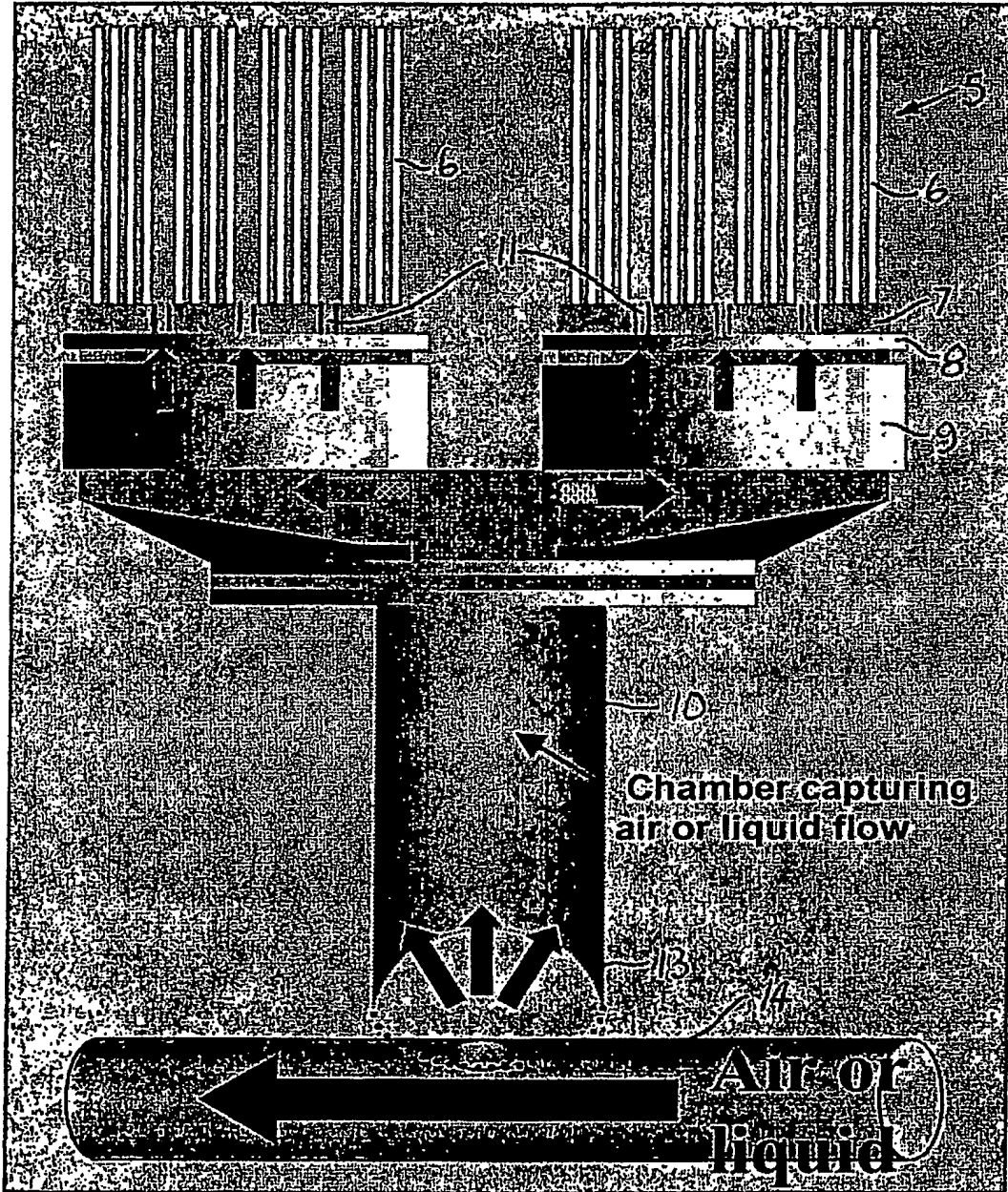


FIG. 3

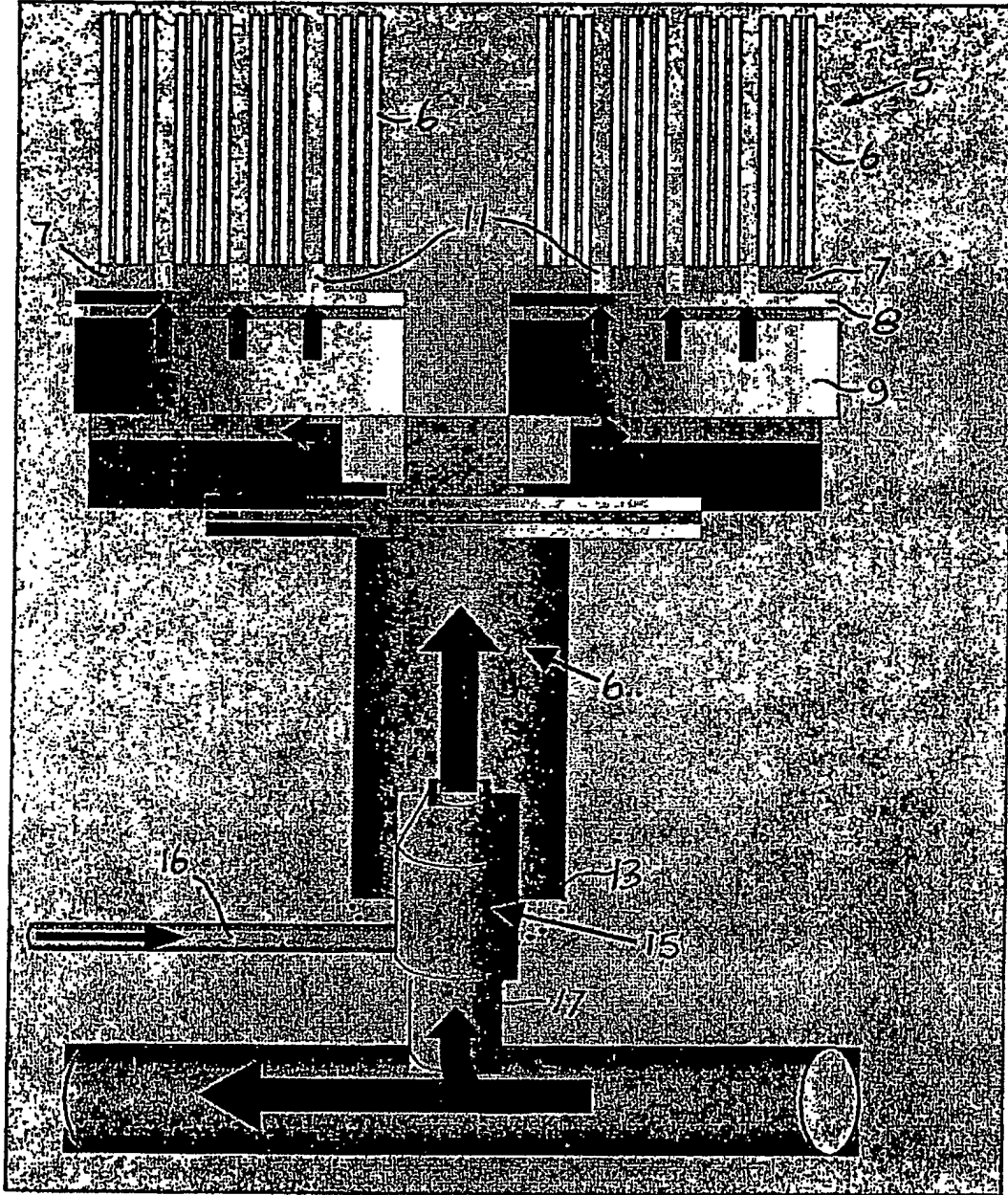


FIG. 4

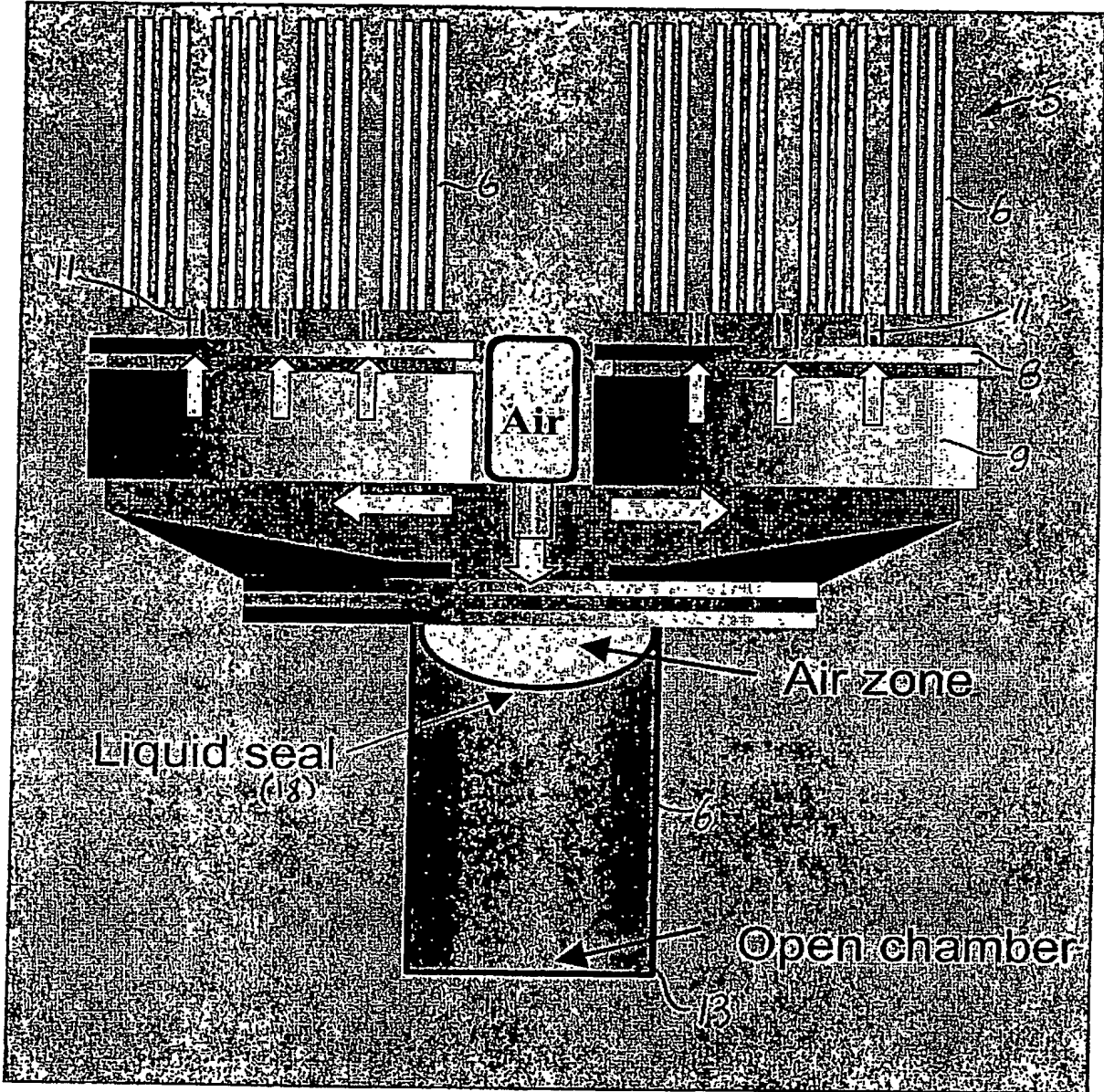


Fig. 5

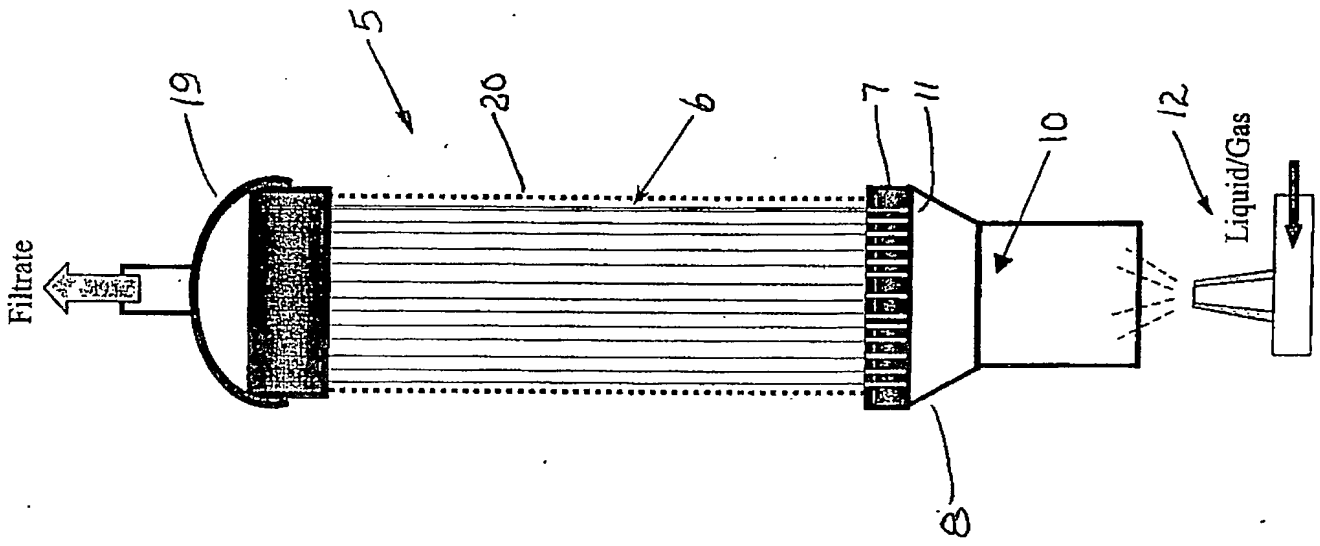


Figure 6 Mixing Chamber Attached to Single Module

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